CALIFORNIA DIVISION OF MINES AND GEOLOGY
FAULT EVALUATION REPORT FER-184
Calico, West Calico, Hidalgo, and related faults,
San Bernardino County, California
by
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INTRODUCTION

The Calico-West Calico-Hidalgo (CWCH) fault zone, which is located in southwestern San Bernardino County, has been examined as part of CDMG'S Fault Evaluation Program. The entire length of this fault zone was mapped by Dibblee (1964, 1966a and b, 1967a and b, 1970). Other workers such as Morton and others (1980), Dokka (1980), and Bull (1978) provided information as to recency of movement and total amount of displacement along the CWCH fault zone. Based on the available data, air photo evidence, and field observations that are described below, several traces of the CWCH fault zone meet the requirements for "sufficiently active and well defined" necessary for zoning under the Alquist-Priolo Special Studies Zones Act (Hart, 1985).

SUMMARY OF AVAILABLE DATA

The Calico-West Calico-Hidalgo (CWCH) fault zone is one of a series of subparallel, northwest-trending, right-lateral, strike-slip faults in the western Mojave Desert. Figure 1 (from Jennings, 1975) shows the CWCH fault zone in relation to other faults in the region. Figure 2 shows the U.S.G.S. topographic quadrangles traversed by the CWCH fault zone. The CWCH fault zone was mapped in its entirety by Dibblee (1964, 1966 a and b, 1967 a and b, 1970) and is shown in detail in Figure 3.

Dibblee shows the CWCH fault zone to have a total length of approximately 75 km (47 miles), trending southeastward from the Calico Mountains to near Twentynine Palms. In several cross-sections Dibblee interprets the fault to be vertical. Right-lateral strike-slip displacement is the main mode of offset along the fault, although a small component of vertical offset is shown in Dibblee's sections.

Bull (1978) includes a reconnaissance appraisal of Quaternary tectonic activity along the CWCH fault zone. He uses five differential equations which interrelate uplift, erosion, and deposition along streams that transect mountain fronts. The results of these equations allow him to divide the major mountain range fronts along the CWCH fault zone into one of three classes of terrain. According to Bull (1978, p. 33), "Class 1 (active) fronts occur in highly active tectonic settings that are generally characterized by active folding and/or faulting during Holocene as well as Pleistocene time. Class 2 (slightly active) mountain fronts generally have ruptured Pleistocene, but not Holocene geomorphic surfaces. Class 3 fronts have generally not been active during the Quaternary."

The CWCH fault zone is divided here into three main segments--the Calico, West Calico, and Hidalgo faults, which will be discussed separately. Other related faults, which are evaluated in this report, will also be discussed when appropriate.

The Calico fault is shown by Dibblee (1964, 1966b, 1970) to extend from the Calico Mountains southeastward to the northeast part of the Rodman Mountains 15 minute quadrangle (Figure 3). In the Calico Mountains the fault is essentially a bedrock feature and somwhat poorly defined. Dibblee shows a few areas labelled on Figure 3 where Pleistocene alluvium is in fault contact with bedrock. But it is not clear whether the alluvium was faulted or deposited against the bedrock. From I-15 southward, the fault is shown concealed for the most part by undifferentiated late Pleistocene and/or Holocene alluvium. Dibblee shows Holocene dune material to be accumulated on the southwest side of the fault. This is due to vegetation which has grown here and trapped the dune sand. The fault is shown to be a ground water barrier at the surface by Dyer (1963). In the vicinity of I-40 (U.S. 66 on Figure 3) Dibblee shows Pleistocene and/or Holocene alluvium to be cut by the Calico fault. Several other localities have been labelled on Figure 3 as having a possible Holocene units faulted by the Calico fault. Bull (1978) classifies the Calico Mountain front as Class 1, active.

On the Rodman Mountains quadrangle Dibblee (1964) shows the West Calico fault to branch from the Calico fault (Figure 3). Several locations along the West Calico fault have been labelled on Figure 3 denoting faulted Pleistocene units. Other areas of possible Holocene offsets are also labelled. Along the southern part of the West Calico fault Dibblee (1966a) shows a fairly straight section of fault with old fan deposits faulted against younger Holocene (?) alluvium. Bull (1978) classifies this range front as Class 1, active.

From the north end of Hidalgo Mountain the West Calico fault continues southeastward along the northeast side of Hidalgo Mountain. Dibblee (1967b) shows some older Pleistocene units to be faulted and questionable evidence of Holocene and/or late Pleistocene age faulting. Bull (1978) classifies this range front as active. Dibblee (1967a) shows the fault concealed by Holocene and/or latest Plesistocene alluvium farther to the south as the fault crosses on to the Deadman Lake quadrangle. Bull (1978) classifies this range front as Class 1, active.

On the west side of Hidalgo Mountain the Hidalgo fault branches from the West Calico fault. Dibblee (1967b) shows evidence of possible Holocene faulting where young fan deposits are in fault contact with bedrock. Bull (1978) classifies this range front as active, class 1. To the south, the Hidalgo fault trends more easterly and crosses over the mountain as mapped by Dibblee. Locally he shows Pleistocene alluvium not to be faulted near the large landslide on the west side of the range (see Figure 3). Dibblee (1967a and b) maps the fault from Hidalgo Mountain southward as a continuous feature through Surprise Spring.

The southernmost segment of the Hidalgo fault has been called the Surprise Spring fault by Moyle (1984). He shows a fairly prominent ground water barrier with high water table on the southwest side of the fault. Dibblee shows the fault to cut Pleistocene age alluvium but shows it concealed by Holocene and/or latest Pleistocene alluvium at Surprise Spring.

Approximately 2 miles east of Surprise Spring, Dibblee (1967a) maps a 4 mile long fault segment labelled fault "A" on Figure 3. He shows the fault cutting Pleistocene alluvium but concealed by Holocene and/or Latest Pleistocene alluvium. Rasmussen (1983) placed trenches across this fault (see Figure 6) and found the fault to cut probable Holocene materials.

Morton and others (1980) used black-and-white, low-sun-angle air photos to produce a photoreconnaissance, interpretive map of "young looking" fault-related features along the CWCH fault zone (see Figure 4a, b). They did not field check the faults mapped. Their annotated strip map shows alignments of scarps and tonal features in younger and older alluvium; as well as alignments of saddles, linear trenches, and drainages etc. in bedrock along the general trend of the fault zone as mapped by Dibblee (see above). Their data comprise the single most important source of information on recently active traces of the CWCH fault zone. Most of the fault-related geomorphic features shown by Morton and others were verified by this writer using photo inspection and/or field inspection during the course of this study (see Figure 4a, b, 5 and 6 and discussion below). Some of Morton's annotations such as "scarps appear to cut youngest alluvium" were strongly suggestive of Holocene activity along the CWCH fault zone.

Various workers have estimated the amount of right-lateral displacement along the CWCH fault zone. Garfunkel (1974) calculated that the Calico and Pisgah faults had displaced volcanic rocks in the Bullion Mountains 40 km to the northwest. Approximately half of this amount, 10 to 20 km, was attributed to (see Fig. 5 of Garfunkel) movement along the Calico fault. Dokka (1983, p. 306) calculates that right-lateral displacement along the Calico fault is 8.2 km. His estimate is based upon the offset of an early Miocene detachment fault he names the Kane Springs Fault.

AIR PHOTO INTERPRETATION AND FIELD OBESERVATIONS

Air photo interpretations and field observations of this writer for the Calico-West Calico-Hidalgo fault zone are mainly included in Figures 4a, 4b, 5, and 6. These data are largely plotted on the photo reconnaissance map of young looking fault features along the CWCH fault zone by Morton and others (1980, sheets 4 and 5). There strip map was used as a base for this writer's data because it shows apparently fault related geomorphic features on a suitably scaled topograhic map. Data for the Newberry 15-minute quadrangle were re-plotted onto new 7.5 minute quadrangles (Figure 5), which were not in existence when Morton and others did their work. In general, the features noted by Morton were verified during this study, and most are accurately located. However, some features shown by by them were either mislocated or could not be verified by this writer. Figure 6 shows data for the Surprise Spring fault and fault A, which were largely unmapped by Morton and others.

The aerial photography used for this study were U.S.D.A., 1953, series AXL. The low-sun-angle photos used by Morton and others were not available. Field inspections along the CWCH fult zone were done from Jan. 26-30, 1987. Earl Hart participated in the field work during this time and also reviewed the air photos.

For purposes ot aiscussion, the CWCH fault zone is divided into three main segments--the Calico, West Calico, and Hidalgo faults--which will be discussed separately.

Calico fault

The Calico fault is generally well-defined by discontinuous strands from Highway I-15 in the Yermo quadrangle southeastward to the powerline in the

Silver Bell Mine quadrangle (Figure 4a). To the northwest of Highway I-15, where the fault passes south and west of the Calico Mountains, the fault is in bedrock and can be mapped as a zone of discontinuous, erosional features which do not suggest that a fault is active. Here, the strike of the fault changes from N35W to N60W and the apparent sense of movement changes from strike slip to oblique-reverse slip. Neither Morton and others or this writer saw any evidence of recent offset along this segment of the Calico fault. The fault cannot be traced through alluvial fans. However, Bull (1978) classifies this mountain front as Class 1, active. No field observations were made in the Calico Mountains area.

Recently active traces of the Calico fault can be identified on air photos as alignments of scarps, linear drainages, sidehill benches, breaks-in-slope, shutter ridges, closed depressions, right-laterally deflected drainages, and offset alluvial fans. Many of these features were field-checked in the Yermo, Harvard Hill, and Newberry Springs quadrangles (Fig. 5). The probability that the Calico fault has been active in Holocene time is strongly suggested by the abundance of relatively fresh, ephemeral features along various segments of the fault. The most notable of these features are the linear scarps and tonals in Holocene and latest Pleistocene alluvium and dunes (see Figures 4a, 4b and 5, locality numbers 1,3,4,17). At localities 18 and 19 on the Newberry Springs 7.5-minute quadrangle (Fig. 5) two closed depressions in latest Pleistocene or Holocene alluvium were observed. The existence of deflected drainages at localities 2 and 20 and elsewhere are indicative of dominant right-lateral displacement along the Calico fault.

West Calico fault

Recent activity along the Calico fault steps right to the West Calico fault south of Locality 6 in the Silver Bell Mine quadrangle (Figure 4a). The West Calico fault is very well defined over most of its length from its junction with the Calico fault southeastward to the area of Hidalgo Mountain. Southeast of Locality 16, the faults is only locally defined. The fault was field checked at Localities 10, 11, and 13 (Figures 4a and 4b).

Good evidence of Holocene activity exists along the West Calico fault but along the southern third of the fault the evidence is particulary convincing. Linear scarps and tonals in Pleistocene and/or Holocene alluvium exist and define the fault to the northwest at localities 7 and 8. From locality 9 southward to the junction with the Hidalgo fault, the West Calico fault is particularly well defined and these features shown on Figure 4b, especially at locality 12, are very youthful looking. Sidehill-benches in older alluvium are well-developed at localities 11, and 13. A sidehill-bench is a very convincing piece of evidence for Holocene movement along a fault. Such a feature on a steep slope would by masked by slope wash unless repeated, recent faulting occurred.

As the West Calico fault crosses to the east side of Hidalgo Mountain it becomes progressively less well defined. Recently active traces were not observed by this writer southeast of locality 15, where a prominent, arcuate scarp was observed both on air photos and in the field. The fault is poorly defined at locality 16. However, fault A (Figure 6) may be a continuation of the West Calico fault (see discussion below).

Hidalgo fault

At the north end of Hidalgo Mountain the Hidalgo fault branches from the West Calico fault and continues southward toward Surprise Spring (Figure 6). South of Surprise Spring the Hidalgo fault becomes progressively more difficult to follow. However, Moyle (1984) does show a ground-water barrier continuing south to near Copper Mountain on the Sunfair 7.5 minute quadrangle. The segment of the Hidalgo fault at Surprise Spring has been called the Surprise Spring fault by Moyle.

The western front of Hidalgo Mountain shows some evidence of latest Pleistocene or Holocene disruption by movement along the Hidalgo fault. Locality 14 on Figure 4 shows a series of short scarps and truncated spurs where Holocene fan deposits are in abrupt contact with bedrock. It is not completely clear whether the young alluvium is faulted or not. However, the freshness of the features are suggestive of Holocene faulting. Bull (1978) classifies this front as class 1, active.

Between Hidalgo Mountain and Surprise Spring (the segment called Surprise Spring fault by Moyle, 1984) the fault becomes a zone of continuous of geomorphic and tonal features in bedrock and older alluvium (Figure 6). Two drainages just north of Surprise Spring are offset in a right lateral sense as well as the drainage at Surpise Spring. At Surprise Springs, the southwest side of the fault is more vegetated than the northeast side, indicating the fault acts as a ground water barrier in latest Pleistocene or Holocene sediments. South of the prominent scarp below Surprise Spring the fault becomes progressively less defined. However, farther south on the Twentynine palms 15-minute quadrangle, Dibblee (1968) maps the continuation of the fault. This segment is treated in another FER by Bryant (1986). Bryant was not able to verify the fault as a well defined or active feature.

Approximately 2 miles east of Surprise Spring Dibblee (1967a) maps a short (3 mile) fault labelled here as Fault "A" (Figure 3). Dibblee shows Fault "A" cutting older (Pleistocene) alluvium and concealed by younger alluvium. Rasmussen and Associates (1983) in a study for a proposed pipeline placed two trenches (shown on Figure 6), across Fault "A". In their trench log descriptions they conclude that Fault "A" cuts sediments of probable Holocene age. The fault is also shown as a groundwater barrier by Moyle (1984). Morton and others map a southwest facing scarp (see locality 23 Figure 6) 0.75 miles north of Fault "A" which is on trend with the fault. This scarp is in Holocene alluvium as mapped by Dibblee. Other west facing scarps and tonals were mapped for this report and are shown on Figure 6 south of locality 23.

SEISMICITY

An examination of 'A' and 'B' quality epicenter locations for the period 1969-1984 (CIT, 1985) shows that there has been some seismic activity on or near the Calico-West Calico-Hidalgo fault zone, especially at the northern and southern ends (see Figure 7).

CONCLUSIONS

The Calico-West Calico-Hidalgo fault zone is a major, right-lateral, strike-slip fault zone which extends 75 km (47 miles) southeastward from the

Calico Mountains to the area west of Deadman Lake. The fault is one of a series of subparallel, closely spaced faults in the central Mojave Desert (Figure 1). The northwest end of the fault zone (the Calico fault), where it passes through the Calico Mountains, is not as well defined and features indicating recent movement are lacking, however, Bull (1978) classified this mountain front into his "class 1" category, "active". From Calico Mountains southward the active traces of the CWCH fault zone are well defined and can be easily followed as discontinuous surface features, mainly linear scarps and other features.

The best evidence of Holocene activity along each of the faults comprising the CWCH fault zone are in the following areas:

Calico fault - The area around Newberry Springs north of Old Highway 66 (Highway 40) Dibblee (1966b) shows Holocene and latest Pleistocene alluvium and clay to be faulted. Field check of the area shows a closed depression along the fault (see Figure 4 locality 18).

West Calico fault - The area north of Hidalgo Mountain has abundant youthful features such as scarps in very latest Pleistocene and/or Holocene alluvium. (see Figure 4 localities 10-12 and 21). Bull (1978) classifies this range front as class 1, "Active".

Hidalgo fault - The west side of Hidalgo Mountain has several youthful looking scarps with Holocene fan deposits in fault contact with bedrock. The freshness of the scarps would seem to make them latest Pleistocene or Holocene in age. This is a class 1 front according to Bull.

Surprise Spring fault - The southern end of the Hidalgo fault has been called the Surprise Spring fault by Moyle (1984). At Surprise Spring a strong groundwater barrier exists in latest Pleistocene and/or Holocene alluvium. South of Surprise Spring the fault becomes progressively less well defined.

Fault "A" - Two miles east of Surprise Spring, Dibblee (1967a) maps a short fault shown to cut older alluvium but concealed by Holocene alluvium. Rasmussen (1983) determined, from trenching that the fault cuts probable Holocene age alluvial deposits. Subtle geomorphic features also suggest that this fault is active.

RECOMMENDATIONS

The principal strands of the Calico-West Calico-Hidalgo fault zone (CWCH) from Highway I-15 to the area of Surprise Spring generally meet the necessary requirements of "sufficiently active" and "well defined", and should be zoned for Special Study. These faults are highlighted in yellow on Figures 4a, 4b, 5 and 6. The fault labelled Fault "A" east of Surprise Spring should also be zoned as shown on Figure 6. References cited should be Morton and others

(1980) and this report. Dibblee (1964, 1966 a and b, 1967 a and b, 1970) should also be cited for confirmation on some quadrangles although his specific traces were not used.

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Report received; I concur with the recommendations.

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